

In This Issue

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In the present Deep Space Network (DSN) ground system for low noise, two-way communications, a major contributor to excess noise temperature is the waveguide diplexer; the antenna microwave device that separates the high-power uplink from the sensitive, low noise receiver. In their article, "X-band Feed Junction Diplexer "Doubles" the DSN," Mark Gatti and Phil Stanton, describe the demonstration of an improved configuration that injects the transmitter signal directly into the feed junction. This feed junction diplexer will reduce the noise temperature by nearly 3 dB for the 70-m antenna X-band system, nearly doubling the two-way communications performance of the DSN's largest antennas!

The Cassini Gravitational Wave Experiment using the Goldstone DSS 25, 34-m BWG antenna requires "4-way" transmit and receive capabilities at X- and Ka-band. Gatti and Stanton, in the

article, "Simultaneous X/Ka-band Demonstration will Benefit Cassini and Others in the DSN," describe the Frequency Selective Surface components, system configuration and the results of the Goldstone R&D station DSS 13 demonstration. This successful demonstration enables the DSN and the Cassini project to plan for this important upcoming experiment.

Steve Lichten reports on the progress of Global Positioning System (GPS) applications in the article, "A Wide Area Differential GPS (WADGPS) System for NASA Positioning and Navigation Application." This system will be fully operational by FY99, eliminating the need for DSN 70-m antenna time for Earth platform calibrations; currently about 1000 hours/year. In addition, the NASA global GPS system will enable fully autonomous onboard satellite navigation, saving considerable resources in NASA ground systems for tracking and

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X-BAND FEED JUNCTION DIPLEXER "DOUBLES" THE DSN

MARK GATTI AND PHIL STANTON

Have you ever considered the mind boggling size of the 70-m antennas that are used to communicate to the spacecraft? Imagine what would have to be done to increase the system receiving performance by nearly 3 dB; or close to a doubling of the amount of data that could be received. This could be accomplished by using a nearly 100-m antenna, or by arraying additional antennas; either conventional approach to improve the

ground antenna gain by 3 dB is very expensive. Alternatively, one could reduce the noise temperature of the receiving system by 3 dB, since the receiving performance is determined by the ratio of antenna gain divided by the system noise temperature, G/T. In the Antenna Systems Work Area within the Telecommunications and Mission Operations Directorate (TMOD) Technology Program, we have successfully done just that: in expen-

"DOUBLES" CONTINUED FROM PAGE 1

sively reduced the system noise temperature in the two-way (simultaneous uplink/downlink) mode by nearly 3 dB!

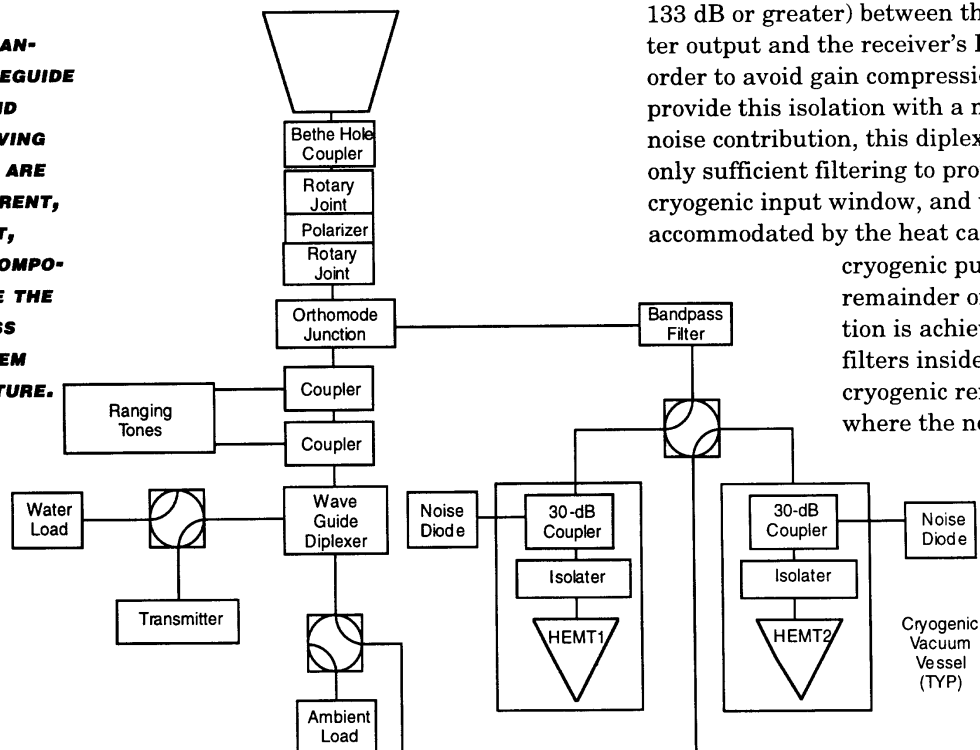
What exactly is the origin of the noise temperature in the Deep Space Network (DSN) receiving systems? At present, the major cause of the noise temperature is not the low noise amplifier (LNA). Instead, the greatest cause for excess noise temperature comes from the way in which existing systems are configured to perform two-way operations. Present DSN X-band diplexed configurations have a number of room temperature waveguide components between the feed horn and the cryogenically cooled LNA. These components include couplers, rotary joints, switches, a waveguide diplexer, a polarizer, and an orthomode junction, as shown in Figure 1. The diplexer routes the transmit signals to the antenna feed horn, preventing that signal from passing to the very sensitive LNA, while simultaneously allowing the weak downlink signal to go through the feed horn, the diplexer, and into the LNA. Current DSN waveguide diplexer designs and signal flow reconfigurations with waveguide switches for alternating between downlink only and the uplink/

downlink two-way mode, result in a lossy signal flow path with resulting high noise temperatures, particularly in the two-way mode.

In recent years, the Antenna Systems Work Area has pursued improved diplexing technologies. The advances in high-electron mobility transistors (HEMTs) LNA noise performance, and demonstrations of improved low-noise amplifier systems stimulated considerations of merging the LNAs with new and unique diplexers. A new, low loss, X-band feed junction diplexer design was developed that reduces the number of ambient temperature components. This new feed junction diplexer (Figure 2) has a much shorter ambient temperature waveguide path length with resultant lower losses and noise temperature than current diplexed DSN waveguide configurations, and is applicable to either BWG or non-BWG antennas. Elimination of the one/two-way waveguide switch not only improves performance, but lowers the implementation, maintenance, and operational costs.

Diplexing the X-band uplink/downlink signals requires a high degree of isolation at the uplink frequency (in this case 133 dB or greater) between the transmitter output and the receiver's LNA, in order to avoid gain compression. To provide this isolation with a minimum noise contribution, this diplexer provides only sufficient filtering to protect the LNA cryogenic input window, and what can be accommodated by the heat capacity of the cryogenic pump. The remainder of the isolation is achieved by using filters inside the LNA cryogenic refrigerator, where the noise contri-

FIGURE 1. A STANDARD DSN WAVEGUIDE DIPLEXED GROUND TRANSMIT/RECEIVING SYSTEM; SHOWN ARE THE MANY DIFFERENT, MOSTLY AMBIENT, TEMPERATURE COMPONENTS THAT ARE THE CAUSE OF EXCESS RECEIVING SYSTEM NOISE TEMPERATURE.



SIMULTANEOUS X/KA-BAND DEMONSTRATION WILL BENEFIT CASSINI AND OTHERS IN THE DSN

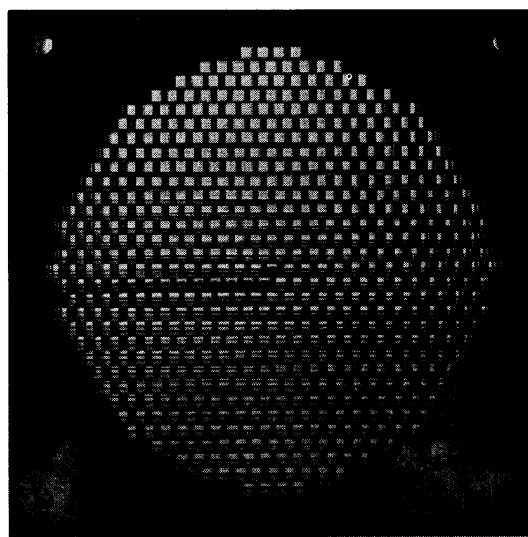
MARK GATTI AND PHIL STANTON

Previously, the Deep Space Network (DSN) transitioned from spacecraft telecommunications systems operating completely at S-band (2.115-GHz uplink, 2.295-GHz downlink) to a simultaneous S/X-band system, then to X-band only (7.167-GHz uplink, 8.415-GHz downlink). The DSN is now transitioning to simultaneous X/Ka-band operation. Now, as then, we are concerned with the manner in which these systems can coexist on a spacecraft or a ground station. Requirements for use of the Ka-band system vary, but include Ka-band receive only, X/Ka-band simultaneous receive only, X/Ka-band receive with X-band transmit, and full four-way diplexing X-band transmit/receive, simultaneously with Ka-band transmit/receive. In fact, the Cassini radio science and gravitational wave experiments depend on various combinations of these basic configurations. In order to quantify the performance of a system that can operate in the complete four-way mode, we have assembled the various Ka-band and X-band technologies and performed a successful demonstration. The result of the demonstration has enabled the Cassini project to plan for its experiments, using the DSN 34-m beam waveguide (BWG) at DSS 25.

The technology used in performing the four-way demonstration was developed by the Antenna Systems and demonstrated by the DSS 13 Evolution Work Areas in the Telecommunications and Mission Operations Directorate (TMOD) Technology Program. The main problem facing the designers is with the diplexing of the uplink and downlink signals. We have developed several new techniques to

perform this diplexing as an alternative to using the standard DSN waveguide diplexer (see this issue and, Issue 4, December 1995) for the X-band frequencies; specifically the use of frequency selective surfaces (FSS) and feed junction diplexers. The losses associated with the use of a waveguide diplexer prohibit the use of such a device in the receive chain of a low-noise system at Ka-band. We therefore applied what was learned at X-band to the Ka-band diplexing problem. Two diplexing techniques were developed; the use of an FSS and a feed junction diplexer. In the demonstration reported in this article, we chose to use the FSS mainly because the development schedule of this item was ahead of the feed junction diplexer development.

Figure 1 is a picture of the prototype FSS developed to split the 32-GHz down



Approx 7" sq

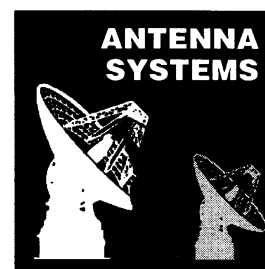


FIGURE 1.
PROTOTYPE 5-LAYER
KA-BAND DICHROIC
PLATE.

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